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Global Carbon Markets

Are There Opportunities for Sub-Saharan Africa?

Elizabeth Bryan

Wisdom Akpalu

Mahmud Yesuf

Claudia Ringler

Environment and Production Technology Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Elizabeth Bryan, International Food Policy Research Institute
Senior Research Assistant, Environment and Production Technology Division
e.bryan@cgiar.org

Wisdom Akpalu, State University of New York-Farmingdale
Assistant Professor

Mahmud Yesuf, Ethiopian Development Research Institute and Addis Ababa University
Fellow

Claudia Ringler, International Food Policy Research Institute
Senior Research Fellow, Environment and Production Technology Division

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ABSTRACT

Global climate change poses great risks to poor people whose livelihoods depend directly on the use of natural resources. Mitigation of the adverse effects of climate change is a high priority on the international agenda. Carbon trading, under the Kyoto Protocol as well as outside the protocol, is growing rapidly from a small base and is expected to increase dramatically under present trends. However, developing countries, in particular Sub-Saharan Africa, remain marginalized in global carbon markets, with Africa’s market share constituting less than 1 percent (excluding South Africa and North African countries). The potential for mitigation through agriculture in the African region is estimated at 17 percent of the global total, and the economic potential (i.e. considering carbon prices) is estimated at 10 percent of the total global mitigation potential. Similarly, Africa’s forestry potential per year is 14 percent of the global total, and the avoided-deforestation potential accounts for 29 percent of the global total. Appropriate climate-change policies are needed to unleash this huge potential for pro-poor mitigation investment in Sub-Saharan Africa. Such policies should focus on increasing the profitability of environmentally sustainable practices that generate income for small producers and create investment flows for rural communities. Pro-poor investments, community development, new research, and capacity building can all help integrate the agriculture, forestry, and land-use systems of developing countries into the carbon trading system, both generating income gains and advancing environmental security. Achieving this result will require effective integration, from the global governance of carbon trading to the sectoral and micro-level design of markets and contracts, as well as investment in community management. Streamlining the measurement and enforcement of offsets, financial flows, and carbon credits for investors is also needed. This review paper begins with an overview of global carbon markets, including opportunities for carbon trading, and the current involvement of developing countries, with a focus on Sub-Saharan Africa. This is followed by an assessment of the mitigation potential and options involving agriculture, land use, and forestry. The major constraints to the participation of Sub-Saharan Africa in global carbon markets are discussed, and options for integrating the region into global carbon markets are proposed.

Keywords: climate change, mitigation, carbon markets, Clean Development Mechanism, Sub-Saharan Africa

ABBREVIATIONS AND ACRONYMS

AAU	Assigned Amount Unit
CCX	Chicago Climate Exchange
CERS	Certified Emissions Reductions
CDCF	Community Development Carbon Fund
CDM	Clean Development Mechanism
CFI	Carbon Financial Instrument
CMM	Coal mine methane
EE	Energy efficiency
ERPA	Emission Reduction Purchase Agreement
ERU	Emission Reduction Unit
EUA	European Union Allowance
EU ETS	European Union Emissions Trading Scheme
FCPF	Forest Carbon Partnership Facility
GHG	Greenhouse gas
HFC	Hydrofluorocarbon
JI	Joint Implementation
LULUCF	and use, land-use change, and forestry
LFG	Landfill gas
NSW GGAS	Australia's New South Wales Greenhouse Gas Abatement Scheme
OECD	Organization for Economic Cooperation and Development
REDD	Reduced emissions from deforestation and degradation
RGGI	Regional Greenhouse Gas Initiative
SSA	Sub-Saharan Africa
UK ETS	United Kingdom Emission Trading Scheme
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
VER	Verified Emissions Reduction
WBCFU	World Bank Carbon Finance Unit

1. INTRODUCTION

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in December 1997 by several industrialized countries and some economies in transition, and the agreement came into force in February 2005. Parties to the agreement have taken on legally binding reductions in greenhouse gas (GHG) emissions, which are responsible for global warming. The protocol allows for a flexible “cap and trade” system that imposes national limits on emissions but also allows countries to engage in emission trading if they desire to maintain or increase their emissions of GHGs.

Within the short period of its existence, global carbon trading has rapidly expanded in volume, value, and scope. The volume of carbon transactions has expanded from 717 $MtCO_2e$[1] in 2005 to 2,983 MtCO2e in 2007, and the total value of these transactions has increased from US$11 billion to US$64 billion (Table 1). The value of transactions within the Clean Development Mechanism (CDM) of the Kyoto Protocol, which involves carbon trading with developing countries, has more than doubled each year between 2005 and 2007. Moreover, outside the Kyoto Protocol, several initiatives to manage GHG emissions are emerging. For instance, in the United States, seven northeastern states signed a memorandum of understanding to reduce emissions in December 2005 (11 American states are now involved in this initiative; see http://www.rggi.org), and California passed a new law to reduce GHG emissions in September 2006. Following a shift in the composition of Congress, the U.S. federal government is widely expected to adopt stronger measures to reduce GHG emissions in 2009. All these events indicate rapid increases in future global carbon trading even beyond 2012, which defines the end of the first emission budget period.

Despite this expansion, Sub-Saharan Africa (SSA) accounts for only 1.4 percent of all registered CDM projects—only 17 out of 1,186 projects (CDM 2008). SSA’s share of CDM projects is nine times smaller than its global share of GHG emissions, including emissions from land use and land-use change, and most of these projects (14 out of 17) are located in just one country, South Africa (CDM 2008; de Gouvello et al. 2008). Given that SSA’s share of projects is smaller than its share of emissions, there is potential for greater inclusion in global carbon markets. These include afforestation/reforestation of degraded lands, cropland management, waste management using composting or landfill gas capture, hydropower, and energy-efficiency projects.

The potential for mitigation through agriculture in the African region has been estimated at 970 $MtCO_2e$ per year by 2030, 17 percent of the global total; and the economic potential, which allows for carbon trading, is estimated to be 265 $MtCO_2e$, 10 percent of the total global mitigation potential (assuming carbon prices of up to US$20 per tCO_2e) (Smith et al. 2008). Similarly, for forestry, Africa’s potential of 1,925 $MtCO_2e$ per year is 14 percent of the global total (Nabuurs et al. 2007). Even more importantly, Africa’s avoided-deforestation potential of 1,160 $MtCO_2e$ per year accounts for 29 percent of the global total (ibid.). Why is this potential underutilized? What are the constraints preventing SSA from effectively participating in global carbon markets? This paper will address these issues in turn.

[1] MtCO2e stands for mega tons of carbon dioxide or equivalent.

Table 1. Carbon markets, volumes, and values

	2005		2006		2007	
	Volume ($MtCO_2e$)	**Value (MUS$)**	**Volume ($MtCO_2e$)**	**Value (MUS$)**	**Volume ($MtCO_2e$)**	**Value (MUS$)**
Allowances						
EU Emissions Trading Scheme	324	8,204	1,104	24,436	2,061	50,097
New South Wales Greenhouse Gas Abatement Scheme	6	59	20	225	25	224
Chicago Climate Exchange	1	3	10	38	23	72
UK Emissions Trading System	0	1	NA	NA		
Subtotal	332	8,268	1,134	24,699	2,109	50,394
Project-based transactions						
Clean Development Mechanism	359	2,651	562	6,249	791	12,877
Joint Implementation	21	101	16	141	41	499
Other compliance and voluntary transactions	5	37	33	146	42	265
Subtotal	384	2,789	611	6,536	874	13,641
TOTAL	717	11,057	1,745	31,235	2,983	64,035

Source: Capoor and Ambrosi 2007, 2008
Note: MtCO2e = mega tons of carbon dioxide or equivalent
MUS$ = million U.S. dollars

The paper is organized as follows. Section 2 provides a general description of how the various carbon markets function and an overview of global climate-change agreements, discusses their significance in terms of volumes traded, and addresses the participation of countries. The main types of assets traded through the CDM and Africa's market share are discussed in Section 3, and Section 4 describes emission statuses and trends by region and sector. Mitigation potential and options relating to agriculture, land use, and forestry are discussed in Section 5. Section 6 outlines the major constraints to the region's participation in global carbon markets. Options for integrating SSA into global carbon markets are discussed in Section 7, and conclusions are presented in Section 8.

2. AN OVERVIEW OF MAJOR CLIMATE-CHANGE AGREEMENTS AND CARBON TRADING ARRANGEMENTS[2]

It is now widely accepted that the atmospheric concentration of GHGs has been increasing rapidly as a result of human activities such as fossil fuel burning and deforestation, leading to global climate change. It is also widely accepted that global climate change would have adverse impacts on the socioeconomic development of many nations (Stern 2007).

The UNFCCC was adopted in 1992 in Rio de Janeiro, at what was informally known as the Earth Summit, in an effort to reduce countries' emission footprints and curb the dangers of global climate change. This convention was the first international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED). Signatories to the UNFCCC are split into two groups: Annex I countries[3] (industrialized countries and countries with economies in transition) and non–Annex I countries (mainly developing countries). Annex I countries and some transitional economies agree to reduce their emissions (particularly carbon dioxide [CO_2]) to target levels below their 1990 emission levels. If these countries cannot do so, they must buy emission credits or invest in conservation. Developing countries have no immediate restrictions under the UNFCCC but may volunteer to join the group of Annex I countries when they are sufficiently developed.

The treaty aimed at reducing emissions of GHGs in order to combat global warming. As originally framed, it set no mandatory limits on GHG emissions for individual nations and contained no enforcement provisions. It is, therefore, considered legally nonbinding. However, the treaty included provisions for updates (called "protocols") that would set mandatory emission limits. The principal update is the Kyoto Protocol, which was adopted in December 1997 in Kyoto, Japan, after intensive negotiations. Most industrialized nations and some Central European economies in transition agreed to legally binding reductions in GHG emissions of an average of 6 to 8 percent below 1990 levels between the years 2008 and 2012, which was defined as the first emission budget period. The United States is the only Annex 1 country that has not ratified the agreement.

As of October 2008, a total of 183 countries and governmental entities had ratified the agreement (representing over 61.6 percent of emissions from Annex I countries). Other countries, such as India and China, that have ratified the protocol, are not required to reduce emissions under the present agreement despite their relatively large populations and high levels of pollution. China, India, and other developing countries were exempted from the requirements of the Kyoto Protocol because they were not the main contributors to the GHG emissions during the industrialization period, which is believed to be causing today's climate change.

A recent world meeting on climate change, which took place in Bali, Indonesia, in December 2007, reaffirms that there will be a market for carbon trading beyond 2012. Major outcomes of the Bali meeting include a commitment by developing countries to include mitigation plans, dependant on developed-country actions, in the next global climate agreement and a new consensus on the importance of avoided deforestation in reducing future emissions (World Bank 2008).

In addition to markets operating under the Kyoto Protocol, there are several other distinct carbon schemes or markets in operation today. Thus, rather than a single carbon market, several carbon markets operate simultaneously, with linkages among them. These schemes all use market-based mechanisms to allocate and trade carbon credits that represent a reduction of CO_2 emissions. Carbon transactions are defined as purchase contracts in which one party pays another party in return for GHG emission reductions or for the right to release a given amount of GHG emissions that the buyer can use to meet its compliance or corporate citizenship objectives vis-à-vis climate-change mitigation. Payment is made

[2] The following sections are based primarily on information in a recent assessment by the World Bank Carbon Finance Unit (Capoor and Ambrosi 2006, 2007, 2008) on the state of and trends in carbon markets.

[3] Annex 1 parties to the UNFCCC are industrialized countries that were members of the Organization for Economic Cooperation and Development (OECD) in 1992, plus countries with economies in transition, including the Russian Federation, the Baltic states, and several Central and Eastern European states.

using one or more of the following forms: cash, equity, debt, convertible debt or warrant, or in-kind contributions such as providing technologies to abate GHG emissions. Carbon transactions can be grouped into two main categories: allowance-based and project-based. Transactions can also be categorized by whether the transaction is intended to meet emission limits under the Kyoto Protocol. See Table 2 for a classification of carbon markets by type of transaction: allowance- versus project-based and Kyoto-compliant versus voluntary.

Table 2. Classification of carbon markets by transaction type and Kyoto compliance

	Trade in Emission Allowances	Project-Based Transactions
Kyoto-compliant	Trade in carbon offsets under European Union Emission Trading Scheme UK Emissions Trading System	All Clean Development Mechanism and Joint Implementation projects
Voluntary, not for compliance under Kyoto	Trade in emission reductions on Chicago Climate Exchange New South Wales Greenhouse Gas Abatement Scheme	Voluntary reduction projects, such as carbon sequestration projects in Africa

Source: Jindal, Swallow, and Kerr 2006

2.1. Allowance-Based Transactions

With allowance-based transactions, the buyer purchases emission allowances created and allocated (or auctioned) by regulators under cap-and-trade regimes, such as Assigned Amount Units[4] (AAUs) under the Kyoto Protocol, or EU Allowances[5] (EUAs) under the EU Emissions Trading Scheme[6] (EU ETS). Such schemes combine environmental performance (defined by the actual level of caps set) and flexibility, through trading, in order for the mandated participants to meet compliance requirements at the lowest possible cost.

Countries that ratify the Kyoto Protocol and accept national limits are allocated AAUs. They then implement their emission targets by allocating quotas to various emitting activities or industrial entities, such as a power plant or paper factory. The EU ETS, the first and largest allowance-based carbon market, was designed to reduce CO_2 emissions of EU member countries (see Table 1 for volumes and values of transactions). The first phase (January 2005–December 2007) was designed to develop the infrastructure for carbon trading in the European Union and to prepare EU countries to meet their commitments under the first commitment phase of the Kyoto Protocol (January 2008–December 2012). Emissions were capped at 6,600 $MtCO_2e$ over the period. As can be seen in Table 1, in its third year (2007), the EU ETS saw over 2 billion allowances changing hands, a sixfold increase over 2005, for a financial value of over US$50 billion. The sectors included under the EU ETS (including the power and heat sector, minerals, metals, and oil and gas industries) comprise about half of EU CO_2 emissions, while GHG emissions from sources not included in the EU ETS, notably transportation and buildings, were to be limited by other policies and measures (Ellerman and Joskow 2008).

[4] An Assigned Amount Unit is equal to 1 tCO_2e. If, for example, an industry is given an emission cap of 80 tons by a regulator and it is able to reduce the production to 70 tons, then the remaining 10 tons can be traded in the form of AAU units.

[5] An EU Allowance is equal to 1 tCO_2e.

[6] The Kyoto Protocol enables a group of several Annex I countries to join together to create a so-called “bubble” or cluster of countries that is given an overall emissions cap and is treated as a single entity for compliance purposes. The European Union elected to be treated as such a group and created the EU ETS as a market within a market. The EU ETS’s currency is the EUA (EU Allowance). The first phase of the scheme was in operation from January 1, 2005, to December 31, 2007, and the second phase is set to run from January 1, 2008, to December 31, 2012.

Challenges from Phase I included an overallocation of allowances due to a lack of accurate data at the outset of the program, volatility in carbon prices,[7] and an increase in electricity prices due to electric power generators that passed along costs to consumers (ibid.). Given the experiences of Phase I, a number of changes will be implemented during Phase II, including no free allowances to the power sector, greater auctioning of allowances, and extension to new sectors, countries, and GHGs (Capoor and Ambrosi 2008).

The UK established its own voluntary allowance-based scheme, the UK Emissions Trading System, which ran from 2002 to 2006. The goals of the scheme were to secure cost-effective GHG emission reductions, give UK companies experience in emission trading in preparation for the EU ETS, and encourage the establishment of an emission trading center in London (Enviros 2006). Participation was voluntary and open to both the public and private sectors. Participants in the UK scheme had the option of applying to opt out of the first phase of the EU ETS. While the scheme provided early experience in emission trading, there is some concern that the scheme did not achieve significant emission reductions given the voluntary nature of the program, concern regarding the complexity of some aspects of the rules, and uncertainty over the time horizon of the scheme (ibid.).

Other allowance-based markets include Australia's New South Wales (NSW) Greenhouse Gas Abatement Scheme (GGAS), which began in January 2003 and is focused mainly on reducing GHG emissions from the power sector. A statewide GHG benchmark is set for the electricity sector, and then retailers and large electricity customers in NSW and in the Australian Capital Territory (ACT) are required (since January 2005) to meet mandatory targets to reduce or offset the emission of GHGs arising from the production of electricity they supply or use, based on their share of electricity demand. Targets are met by purchasing certificates (NSW Greenhouse Abatement Certificates,[8] or NGACs) created by accredited abatement certificate providers through project-based emission-reduction activities. NGACs are generated through the following activities: low-emission generation of electricity and improved generator efficiency, activities that result in reduced consumption of electricity or on-site generation of electricity, and carbon sequestration through forests. In 2007, after ratifying the Kyoto Protocol, the Australian government announced that it would introduce a domestic emission trading scheme by 2010. It is anticipated that the NSW scheme will be integrated into the new national scheme with more ambitious targets.

The Chicago Climate Exchange (CCX) is a voluntary but legally binding[9] commitment- and allowance-based carbon market. The commodity traded on the CCX is the Carbon Financial Instrument (CFI) contract.[10] CFI contracts are comprised of exchange allowances—which are issued to emitting members in accordance with their emission baseline and the CCX Emission Reduction Schedule—and exchange offsets, which are project-based credits (discussed in the following section). By the end of Phase I in December 2006, all members were to have reduced direct emissions by 4 percent below a baseline period of 1998–2001 (Capoor and Ambrosi 2006, 2007). Phase II, which extends the CCX reduction program through 2010, will require all members to reduce GHG emissions by 6 percent below the baseline by 2010 (ibid.).

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[7] The price per ton of CO_2 or equivalent has varied over time and reached a peak in spring 2006 of around 30 euros per ton of CO_2 (Capoor and Ambrosi 2006, 2007). High allowance prices, driven largely by high global energy costs, dropped precipitously in April 2006 upon the release of more accurate, verified emission data. Late in the trial phase (May 2007), there was another sharp decline in allowance prices because there were no provisions for banking emission reductions for use in the second phase of the program (Ellerman and Joskow 2008).

[8] 1 NGAC = 1 tCO_2e

[9] Compliance with the CCX Emission Reduction Schedule is enforced by the CCX Environmental Compliance Committee and is monitored and verified by the Financial Industry Regulatory Authority (FINRA). Members whose emissions do not meet annual emission-reduction targets must use banked allowances from previous years or purchase CFI contracts on the CCX electronic trading platform to meet their compliance requirements.

[10] 1 CFI contract = 100 $MtCO_2e$

2.2. Project-Based Transactions

With project-based transactions, the buyer purchases emission credits from a project that can verifiably demonstrate GHG emission reductions compared with the level of emissions that would have been produced in the absence of the project. The most notable examples of such activities are under the CDM and the Joint Implementation (JI) schemes of the Kyoto Protocol.

Next to the EU ETS, the largest emission reductions have come from the CDM and, to a lesser extent, the JI (see Table 1). An overwhelming majority (about 91 percent) of primary transactions for project-based credits have come from CDM activities, which reduced emissions by 791 $MtCO_2e$ in 2007, more than double 2005 volumes (see Table 1). The CDM is an arrangement under the Kyoto Protocol (Article 12) allowing countries with GHG reduction commitments (Annex I countries) to invest in emission-reducing projects in developing countries as an alternative to making more costly emission reductions in their own countries. JI is a similar arrangement, which allows Annex 1 countries to invest in emission-reduction projects in other Annex 1 countries. Generally this tends to lead to investments in emission-reducing projects in countries with economies in transition, such as the Russian Federation, the Baltic states, and several Central and Eastern European states (see the Appendix for more details on the CDM). Despite a more than twofold increase in the volume of transactions traded over the 2005–2007 period, the dynamic of the project-based market is currently changing, as buyers have become more cautious due to delivery and issuance challenges, the current global financial crisis, and continuing uncertainty about the role of the CDM and JI after 2012; consequently, the number of projects in the pipeline has decreased from its peak in July 2007 (Capoor and Ambrosi 2008).

Once the project-based credits are issued and delivered, they are at that time fundamentally the same as allowances. Unlike allowances, however, project-based credits are compliance assets that need to be “created” through a process that has certain inherent risks (for instance, regulation, project development, and performance) and can involve significantly higher transaction costs. Such risks are addressed through contractual provisions that define how they are allocated between parties, and these risks, along with other factors, are reflected in the value of the transaction.

There is also a growing retail carbon segment that sells emission reductions to individuals and companies seeking to offset their own carbon emission footprints. Reports of increased interest on the part of banks, credit card issuers, private equity funds, and others suggest that this segment could grow exponentially if only there were a credible, voluntary standard for such assets.

According to recent assessments by Capoor and Ambrosi (2006, 2007), the main buyers of project-based credits are European private buyers interested in the EU ETS, government buyers interested in Kyoto compliance, Japanese companies with voluntary commitments under the Keidanren Voluntary Action Plan,[11] U.S. multinationals operating in Japan and Europe or preparing in advance for the Regional Greenhouse Gas Initiative (RGGI) in the Northeastern U.S. states or the California Assembly Bill 32[12] establishing a statewide cap on emissions, power retailers and large consumers regulated by the NSW market in Australia, and North American companies with voluntary but legally binding compliance objectives in the CCX.

There is also a growing retail carbon segment that sells emission reductions to individuals and companies seeking to offset their own carbon emission footprints. Reports of increased interest on the part of banks, credit card issuers, private equity funds, and others suggest that this segment could grow exponentially if only there were a credible, voluntary standard for such assets.

[11] This plan, which covers a wide range of industries, is a voluntary effort devised by the Nippon Keidanren (Japan Business Federation) in which each industry uses its own discretion to set targets for GHGs.

[12] This bill requires the state board to adopt regulations to require the reporting and verification of statewide GHG emissions and to monitor and enforce compliance with this program.

2.2.1. The CDM

CDM projects produce Certified Emission Reductions (CERs), and JI projects produce Emission Reduction Units (ERUs). CERs and ERUs[13] are overwhelmingly bought from project developers by funds or individual entities, rather than being exchange-traded like EUAs. Because the creation of these instruments is subject to a lengthy process of registration and certification by the UN, and the projects themselves require several years to develop, this market is at this point almost completely a forward market in which purchases are made at a deep discount to their equivalent currency and are almost always subject to certification and delivery (although up-front payments are sometimes made). A CDM project must provide evidence that emission reductions are additional to any reductions that would have occurred without the project. Thus, projects must pass through a rigorous public registration and issuance process and be approved by designated national authorities.[14] The CDM is overseen by an executive board.

Major CDM assets and technologies transacted include industrial gases; methane (CH_4); clean energy; land use, land-use change, and forestry (LULUCF); and agroforestry credits. Table 3 presents a complete list of projects eligible for the CDM.

Table 3. Categories of projects that are CDM activities

1. Energy industries (renewable or nonrenewable sources)
2. Energy distribution
3. Energy demand
4. Manufacturing industries
5. Chemical industries
6. Construction
7. Transport
8. Mining and mineral production
9. Metal production
10. Fugitive emissions from fuels (solid, oil, and gas)
11. Fugitive emissions from production and consumption of halocarbons and sulfur hexafluoride
12. Solvent use
13. Waste handling and disposal
14. Afforestation and reforestation
15. Agriculture

Source: Jindal, Swallow, and Kerr 2006

According to the World Bank (Capoor and Ambrosi 2008), the volumes transacted from clean-energy projects (renewable energy, fuel switching, and energy efficiency) reached 358 $MtCO_2e$ in 2007 (64% market share, compared to just 33% in 2006 and 14% in 2005). Energy-efficiency projects at large industrial facilities account for the majority of these emission-reduction transactions (Figure 1). However,

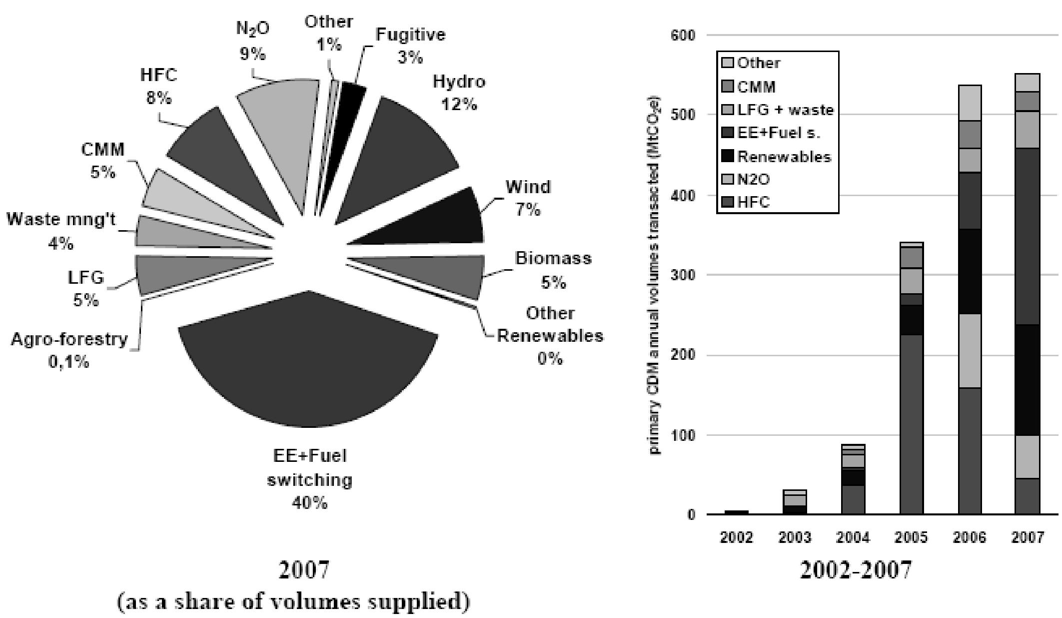
[13] One CER and one ERU are each equal to 1 tCO2e. Note that there are two categories of CDM: primary and secondary. The primary CDM transaction refers to the first sale of CERs from the project owner to the buyer, and the secondary CDM (or secondary CER market) refers to a situation in which a secondary seller sells guaranteed CER (gCER) contracts that are secured through a slice of its carbon portfolios. This includes primary project developers providing project-specific guarantees, often along with credit enhancement through the balance sheet of a highly rated bank (Capoor and Ambrosi 2007, 2008).

[14] Designated operational entities at the national level have the role of verifying whether the project contributed to sustainable development objectives. Public funding for CDM project activities must not result in the diversion of official development assistance.

high up-front costs and unnecessary monitoring complexity have limited the expansion of demand-side energy-efficiency projects. Industrial gases have become less important in the CDM market: projects for the destruction of hydrofluorocarbon 23 (HFC23)[15] have continued to decrease, from a 67 percent share of the CDM market in 2005 to 34 percent and 8 percent in 2006 and 2007, respectively. Projects for the destruction of nitrous oxide (N_2O),[16] another potent GHG with high global-warming potential, started to appear in the transaction database in 2006. N_2O projects captured a 13 percent share of volumes transacted in 2006 and 9 percent in 2007.

Projects for the reduction of coal mine methane (CMM)[17] and landfill gas (LFG) projects each represent 5 percent of the CDM market. CMM constitutes a larger share of the JI market, with a 27 percent market share. LFG[18] projects showed weak project performance and delivery yield (which is the ratio of actually issued CERs to the expected emission reductions) in the early set of issued CERs. Reasons cited include, among others, overestimation of the potential generation of gas at the modeling stage, inadequate design of gas capture systems, suboptimal operation of the landfills, and other external factors. In addition to low performance yields, other barriers to LFG projects include the lack of awareness and capacity of municipalities and the absence of appropriate regulatory frameworks (Capoor and Ambrosi 2008).

Figure 1. Share of CDM project types



Source: Capoor and Ambrosi 2008
Note: CMM=coal mine methane, LFG=landfill gas, HFC= hydrofluorocarbon, EE=energy efficiency

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[15] HFC23 is a by-product of the manufacture of the refrigerant hydrochlorofluorocarbon (HCFC) 22. HFC23-destruction projects provide a cheap way to make money in a small number of industrial sites in a handful of developing countries. However, they provide little discernible sustainable development benefit to those countries.

[16] N2O is an unwanted by-product of the manufacture of nitric acid in chemical processing plants. It is a potent GHG with strong warming potential.

[17] Methane (CH4) is produced from underground and surface mines, and as a result of post-mining activities, including coal processing, storage, and transportation. It is a potent GHG, and a range of projects have been developed to reduce CH4 emissions, including natural gas pipeline injection, electric power production, co-firing in boilers, district heating, mine heating, coal drying, vehicle fuel, flaring, and manufacturing and industrial uses such as feedstock for carbon black, methanol, and dimethyl ether production.

[18] Landfill gas is the biological off gas from the anaerobic decomposition of organic material.

Carbon credits delivered from renewable energy have been increasing since 2005: in 2007, hydropower projects constituted 12 percent of the CDM market, followed by wind projects at 7 percent and biomass projects at 5 percent. Carbon assets from agroforestry and LULUCF were only 0.1 percent of CDM volumes transacted in 2007 due to their regulatory complexity and limited market access to the EU (ibid.).19 However, the proven community benefits and competitive costs20 may result in some additional demand from public buyers, including European governments and those in Japan, New Zealand, and Canada.

Moreover, eligible LULUCF activities are limited to afforestation and reforestation, which further explains the dearth of projects in this category. Large classes of LULUCF assets, including soil carbon sequestration, fire management, and avoided deforestation, are attractive opportunities to promote sustainable development in Africa and in other natural resource–based economies but are excluded from the CDM and other regulatory markets (Harris 2006).

2.2.2. The CCX

The CCX also accepts project-based credits called exchange offsets, which are generated by qualifying offset projects. Offset projects can be registered by members,[21] offset providers, and offset aggregators. Offset providers and offset aggregators do not have significant GHG emissions but can register offset projects and sell the exchange offsets created.[22] The inclusion of offsets is intended to expand market participation to include sectors and locations not subject to an emissions cap, optimize the market so that the maximum GHG mitigation is generated per dollar spent, and realize important ecological and social co-benefits, such as local environmental improvement and greater economic opportunities in developing countries. The CCX has developed simple, standardized rules for issuing CFI contracts for several types of projects: agricultural methane, coal mine methane, landfill methane, agricultural soil carbon, rangeland soil carbon management, forestry, renewable energy, and destruction of ozone-depleting substances. Projects related to energy efficiency and projects eligible for the CDM are approved on a project-by-project basis (CCX 2008). All CCX projects are subject to verification of eligibility and performance by qualified independent entities.[23]

Eligible projects for carbon emission reductions via agricultural soil carbon sequestration include continuous conservation tillage and grass planting. Conservation tillage projects must meet a minimum five-year contractual commitment to continuous no-till or strip-till and leave at least two-thirds of the soil surface undisturbed and at least two-thirds of the residue remaining on the field surface. CFI contracts are issued for conservation tillage at a rate between 0.2 and 0.6 metric tons of CO_2 per acre per year, and carbon sequestration projects must be enrolled through a CCX-registered offset aggregator.

Contracts for forest carbon emission reductions are issued for projects involving reducing deforestation and degradation, afforestation and reforestation, forest management to increase stand- and landscape-level carbon density, and increasing off-site carbon stocks in wood products and enhancing product fuel substitution (CCX 2008). Managed forest projects (reducing deforestation and degradation), which are not included in other exchanges, earn offsets for the additional net carbon sequestered in their forest stocks from the previous year (i.e., carbon sequestered from additional forest growth less carbon lost due to harvesting activities). In order to earn offsets, forest owners must (1) provide evidence that all

[19] The EU ETS currently does not allow market access for any assets from LULUCF activities.

[20] LULUCF emission-reduction purchase agreements typically include post-2012 vintages and discount prices to allow for replacement credits.

[21] Entities that have significant GHG emissions are eligible to submit offset project proposals only if they are CCX members that have committed to reduce their own emissions.

[22] Offset projects involving less than 10,000 tCO_2e per year should be registered and sold through an offset aggregator.

[23] A diverse group of international entities have been authorized to provide project verification. Verifiers inspect project performance data (e.g., metered methane flows, electricity production data, tree measurements, visual inspection) and calculations to confirm a project's actual annual GHG destruction, sequestration, or emission avoidance (e.g., due to energy efficiency or renewable energy projects). An offset project is subject to initial verification as well as annual verification for the duration of its enrollment in the CCX.

their forest holdings are sustainably managed through certification from agencies or schemes endorsed by the Programme for the Endorsement of Forest Certification schemes (PEFC) Council or through other certification schemes approved by the CCX Committee on Forestry, (2) quantify sequestered carbon either using a growth-and-yield model or by calculating inventory on an annual basis, and (3) pass a case-by-case review by the CCX Committee on Forestry.

Thus, a wider range of projects are considered eligible for inclusion in the CCX compared to other carbon markets, including the Clean Development Mechanism (CDM) under the Kyoto Protocol, which is specifically designed to include developing countries. Including emission reductions from projects related to agricultural soil carbon sequestration and forestry provides an opportunity for participation by countries in SSA.

2.2.3. Other Voluntary Markets

Outside the CCX, there are a wide range of voluntary transactions that take place but are not driven by any emissions cap. These markets, therefore, do not trade in allowances, but rather purchase project-created offsets or credits. These credits are often referred to as verified (or voluntary) emission reductions (VERs), or simply as carbon offsets. However, voluntary buyers may also purchase credits from the compliance markets or the CCX. In 2007, offset-generating projects were very diverse, with the largest share of projects related to energy efficiency (18 percent), renewable energy (20 percent), methane destruction[24] (16 percent), and forestry or land-based projects (18 percent) (Hamilton et al. 2008). Forestry and land-based projects include projects related to afforestation/reforestation (10 percent), avoided deforestation (5 percent), and agricultural soil carbon sequestration (3 percent). The volume transacted in voluntary markets increased dramatically from 5 $MtCO_2e$ in 2005 to 42 $MtCO_2e$ in 2007 (see Table 1).

Buyers enter voluntary markets in order to manage their climate-change impacts, to improve public relations, to prepare for upcoming regulation, to resell credits at a profit, or for philanthropic purposes. Suppliers in the offset market include retailers selling offsets online, conservation organizations hoping to harness the power of carbon finance, developers of potential JI or CDM projects with credits that for a variety of reasons cannot currently be sold into the regulated markets, project developers primarily interested in generating VERs, and aggregators of credits (Hamilton et al. 2008). Sellers can be categorized into three major types: project developers that develop GHG emission reductions through offset projects, aggregators or wholesalers that sell offsets in bulk and often have ownership of a portfolio of credits, and retailers who sell small amounts of credits to individuals or organizations, often online, and have ownership of a portfolio of credits. In some cases, brokers are involved to facilitate transactions between sellers and buyers (ibid.).

2.3. The World Bank Carbon Finance Unit

In an effort to ensure that developing countries benefit from international efforts to address climate change, the World Bank has also become involved in carbon financing and capacity building (WBCFU 2006). The World Bank Carbon Finance Unit (WBCFU) purchases project-based GHG emission reductions in developing countries and countries with economies in transition using contributions from governments and companies in Organization for Economic Cooperation and Development (OECD) countries. The emission reductions are purchased through one of the World Bank–managed carbon funds on behalf of the contributor, and within the framework of the Kyoto Protocol's CDM or JI scheme.

These carbon funds—including the Community Development Carbon Fund (CDCF), the BioCarbon Fund, and the Forest Carbon Partnership Facility (FCPF)—specifically target poorer countries and, in the case of the BioCarbon Fund, rural areas of developing countries. The CDCF, which became operational in March 2003, supports projects that combine community-development attributes with emission reductions to create "development plus carbon" credits, and will significantly improve the lives

[24] Methane-destruction projects include projects related to coal mine methane, LFG, and livestock.

of the poor and their local environment. The BioCarbon Fund, which started in May 2004, aims to enhance the role of LULUCF emission-reduction projects within carbon markets and the CDM. By targeting projects that sequester or conserve GHGs in forests and agro-ecosystems, the BioCarbon Fund is intended to extend the benefits of the carbon market to the poorest rural areas and to the local environment (BioCarbon Fund 2007). The FCPF was launched at the UNFCCC meeting in Bali, Indonesia, in December 2007 but has not yet been operationalized. The FCPF focuses on reducing emissions from deforestation and degradation (REDD) by estimating national forest carbon stocks, monitoring sources of forest emissions, and implementing a carbon finance mechanism through which developing countries would be paid for measurable and verifiable emission reductions (WBCFU 2008).

Unlike other World Bank development products that lend or grant funds to projects, the Carbon Finance Unit purchases emission reductions, paying for them periodically, following verification by a third-party auditor. By facilitating the participation of developing countries and economies in transition in the emerging carbon market, the World Bank aims to make progress toward reducing poverty through environment and energy initiatives. In particular, the Carbon Finance Unit intends to reduce the transaction costs of global carbon markets, support sustainable development, and extend the benefits of carbon trading to the poorer communities of the developing world.

3. AFRICA'S SHARE OF GLOBAL CARBON MARKETS AND POTENTIAL

As the largest project-based market with a focus on developing countries, the CDM provides the largest market for carbon offset projects in SSA countries. On the demand side, European buyers dominated the CDM market in 2007, with 90 percent of volumes transacted (Capoor and Ambrosi 2008). This was a change over 2005, when Japanese and European buyers had a similar market share. According to a recent World Bank assessment, within Europe, the UK had a 59 percent share of volumes transacted on the CDM (up from 15 percent in 2005), consolidating its leadership position as the carbon finance hub for the world. Private sector players were the main buyers of CDM assets in 2006, with 79 percent of CDM volumes transacted in 2007. On the supply side, China dominated the CDM market in 2007, with about 73 percent of CDM volumes transacted, followed by India (6 percent), Brazil (6 percent), the rest of Asia (5 percent), and the rest of Latin America (5 percent) (Capoor and Ambrosi 2008). In 2007, Africa's share was 5 percent, with nearly two-thirds of that volume being from either North Africa or South Africa. The other countries of SSA account for just over 10 $MtCO_2e$ (ibid.).

The above information indicates a systematic bias in favor of large, industrial opportunities in the current global carbon market. Despite some notable gains over the past year, African projects still represent a small fraction of the entire CDM pipeline (Robinson and O'Brien 2007). Africa's share of the CDM market increased from 3 percent in 2005 and 2006 to 5 percent in 2007 (Capoor and Ambrosi 2006, 2007, 2008). At the end of October 2008, 27 projects from Africa (and only 17 from SSA) were registered by the CDM, out of a total of 1,186 projects for all developing countries (ibid.). In terms of volumes, contracted projects in Africa amount to about 50 $MtCO_2e$, with more than 20 $MtCO_2e$ transacted in 2007 alone. Most of the investments in SSA are directed toward South Africa (ibid.).

Africa's share of the projects funded by the WBCFU is somewhat higher. Out of a total of 90 projects that have received Emission Reduction Purchase Agreements (ERPAs),[25] 16 projects are in SSA countries (i.e., 18 percent). While this represents an improvement over the CDM, there remains some difficulty in expanding carbon business in much of Africa, given the current restrictions on LULUCF projects, where Africa might have a comparative advantage.

However, Africa has significant mitigation potential, particularly in the agriculture and forestry sectors and has demonstrated innovation with projects in the areas of afforestation and reforestation. These projects will sequester GHGs and also direct financial benefits to members of the local communities from the payment for environmental services and the trade in nontimber forest products (see Capoor and Ambrosi [2006] for a detailed description of the projects). These projects include the Green Belt Movement Project in Kenya, which will reforest 1,800 hectares of indigenous species and is expected to sequester about 0.375 $MtCO_2e$ by 2017. The project is also expected to reduce erosion, protect water sources, regulate water flows, and improve biodiversity. In addition, the Andasibe-Mantadia Biodiversity Corridor Project in Madagascar, which combines reforestation of 3,020 hectares with an avoided-deforestation component, is expected to restore degraded soils and lands and stabilize hydrological flows through the creation of biodiversity corridors between protected reserves and to improve native species, while sequestering approximately 0.2 $MtCO_2e$. Third, the Acacia Plantations Project in Niger will develop 8,800 hectares of degraded land, mostly managed by local communities, to promote sustainable agroforestry and is expected to sequester about 0.5 $MtCO_2e$. Fourth, the Nile Basin Reforestation Project in Uganda will establish a plantation of pine and mixed native species in grassland areas and is expected to sequester around 0.11 $MtCO_2e$ by 2012 and around 0.26 $MtCO_2e$ by 2017. Projects under the BioCarbon Fund administered by the World Bank include two soil carbon sequestration projects in western Kenya.

Thus, opportunities in SSA that have the potential to contribute to real emission reductions through projects in these sectors should be further explored and made part of the CDM and other carbon markets. Yet a number of constraints, as discussed below, hinder greater SSA participation in global

[25] ERPAs are the contracts that govern the sale and purchase of measurable emission reductions.

carbon markets. Facilitating the participation of SSA in the CDM and other carbon markets would encourage the development of innovative ways to sequester carbon and deliver strong local community, environmental, and economic benefits (Capoor and Ambrosi 2006). However, greater participation by SSA countries in the CDM would require a revision of the CDM rules, which tend to exclude the types of projects through which SSA could participate.

4. EMISSION STATUS AND TRENDS

4.1. Emission Status

While SSA's contribution to global emissions is relatively small, there is potential for SSA to contribute to climate-change mitigation, particularly in the forestry and agriculture sectors. This section discusses the contributions of land-use change and agriculture to global GHG emissions and presents SSA's potential to contribute to GHG emission reductions.

Population and economic growth have placed pressure on agriculture to produce more food. The resulting growth in food production has had serious implications for the environment and natural resources. Over the last four decades, the area of land occupied by agriculture has increased dramatically in developing countries and is projected to increase into the future (see Table 4), particularly in Africa and Latin America, where there is a greater amount of uncultivated arable land (Smith et al. 2007a).

Table 4. Agricultural land use in the last four decades

	Agricultural Area (M ha)					Change 1960s–2000s	
	1961–70	**1971–80**	**1981–90**	**1991–2000**	**2001–05**	**Percent**	**M ha**
Africa	1,057	1,071	1,085	1,111	1,137	8	80
Eastern Africa	288	297	301	292	298	4	10
Central Africa	156	157	159	159	160	2	4
Northern Africa	207	212	216	233	240	16	33
Southern Africa	167	164	163	167	168	1	1
Western Africa	240	241	246	259	271	13	32
Americas	1,098	1,139	1,172	1,198	1,203	10	105
Asia	1,078	1,129	1,237	1,618	1,686	56	608
Europe	783	781	781	520	481	-39	-302
Least-developed countries	725	734	746	761	782	8	57
World	4,506	4,623	4,768	4,928	4,972	10	467

Source: FAOSTAT 2008
Note: M ha = million hectares

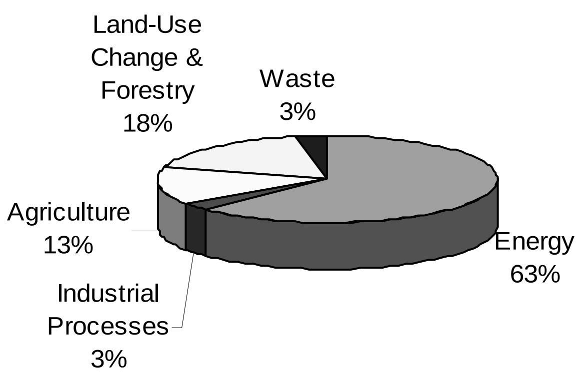
Land-use change accounts for a significant portion of GHG emissions, including CO_2, N_2O, and CH_4. According to Lal (2004), the conversion of natural ecosystems into agricultural areas depletes the carbon content in soils by as much as 75 percent. Deforestation and other land-use changes are responsible for a large share of CO_2 emissions, while agricultural activities such as microbial decay or the burning of plant litter and soil organic matter also contribute a small amount (less than 1 percent) (Smith et al. 2007a).

Agricultural production contributes 13 percent of GHG emissions (see Figure 1). This share includes a large amount of non-CO_2 emissions: in 2005, agriculture contributed about 47 and 58 percent of total emissions of CH_2 and N_2O, respectively (Smith et al. 2007a). N_2O emissions come mainly from fertilizers and manure applied to soils and accounted for 38 percent of total non-CO_2 emissions from agriculture in 2005 (USEPA 2006a). CH_4 emissions from enteric fermentation (livestock) account for the largest share of non-CO_2 emissions in agriculture, accounting for 32 percent of total non-CO_2 emissions in 2005 (ibid.). Biomass burning (12 percent), rice production (11 percent), and manure management (7 percent) account for the remaining non-CO_2 emissions from agriculture (Smith et al. 2007a).

While these two sets of activities (LULUCF and agricultural production) are often dealt with separately in the literature and in practice (by the forestry and agriculture sectors), the two are closely related, as increasing demand for food production triggers land-use changes such as deforestation to make way for expanding agricultural lands. In addition, options for mitigating GHG emissions overlap both sets of activities. For instance, better cropland management to increase the productivity of agricultural lands will also reduce the conversion of forest to agricultural lands.

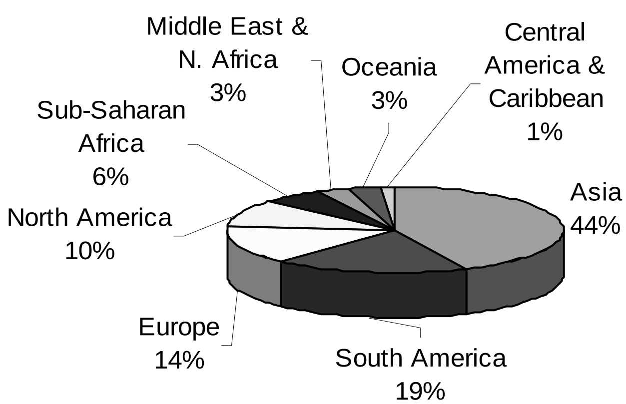
Figure 2 shows that LULUCF and agricultural production together accounted for 31 percent of global GHG emissions in 2000. While developed countries are responsible for the majority of emissions from the energy sector, developing countries are largely responsible for emissions from agricultural production and LULUCF. Figures 3 and 4 show how GHG emissions vary by region, with Asia and South America as the largest emitters of GHGs from agriculture and LULUCF. Sub-Saharan Africa also contributes 6 percent of global emissions from agriculture and 15 percent of emissions from land-use change and forestry.

Figure 2. Share of global total greenhouse gas emissions by sector, year 2000



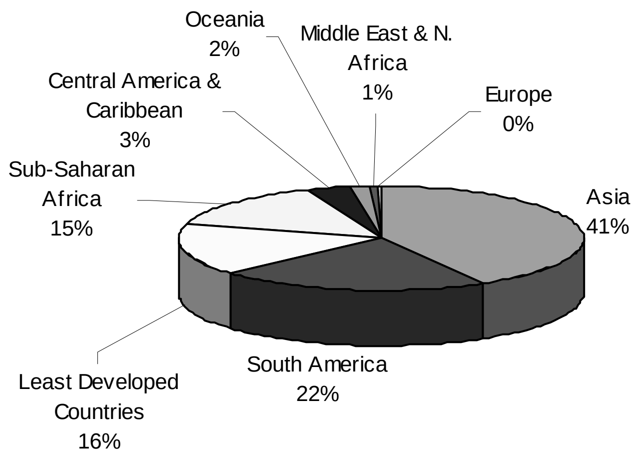
Source: Data drawn from WRI 2008

Figure 3. Regional emissions from agriculture, year 2000 (methane and nitrous oxide)



Source: Data drawn from WRI 2008

Figure 4. Regional emissions from land-use change and forestry, year 2000 (carbon dioxide)



Source: Data drawn from WRI 2008

Globally, emissions of CH_4 and N_2O from agriculture increased by 17 percent from 1990 to 2005 (USEPA 2006a). The increase in global emissions from agricultural production was driven by developing countries; while emissions from agriculture in developed countries are decreasing, emissions from agriculture in developing countries are on the rise, canceling out the reductions made in developed countries over the 1990–2005 period (ibid.). While SSA's contribution to GHG emissions through agriculture is relatively small (6 percent of the global total), there is potential to further reduce emissions. Similarly, between 2000 and 2005 global deforestation continued at an alarming rate of 12.9 million hectares per year due to the expansion of agricultural land and settlements, infrastructure development, and unsustainable logging practices—although this rate represents a slight decrease in deforestation from the rate of 13.1 million hectares per year in the 1990s (Nabuurs et al. 2007). Taking afforestation and reforestation efforts into consideration, the net loss of forest areas is somewhat less: 7.3 million hectares per year between 2000 and 2005 and 8.9 million hectares per year in the 1990s (ibid.). The net decreases in forest areas are driven mainly by forest biomass decreases in developing regions (particularly Africa, Asia, and South America); forest areas are expanding in developed regions such as Europe and North America (ibid.). Table 5 shows the declining carbon stock in living biomass in Africa and other developing countries.

Table 5. Carbon stock in living biomass

	Carbon Stock in Living Biomass ($MtCO_2$)		
Region	1990	2000	2005
Africa	**241,267**	**228,067**	**222,933**
Asia	150,700	130,533	119,533
Europe	154,000	158,033	160,967
North and Central America	150,333	153,633	155,467
Oceana	42,533	41,800	41,800
South America	358,233	345,400	335,500
World	1,097,067	1,057,067	1,036,200

Source: Nabuurs et al. 2007
Note: $MtCO_2$ = mega tons of carbon dioxide

However, the extent to which carbon stock losses due to deforestation in tropical zones are offset by expanding forest areas in the boreal and temperate zones is an area of disagreement among researchers, particularly between studies that use land observations and those that use top-down models, which tend to produce higher estimates of carbon sinks (ibid.).

4.2. Emission Trends (Baseline Scenarios)

GHG emissions from agriculture are expected to increase in the future, given increasing demand for agricultural products and changing food preferences (USEPA 2006b). Table 6 presents the baseline trends for emissions of N_2O and CH_4 from various agricultural activities. In each of these activities, GHG emissions are projected to increase from their 1990 levels. N_2O emissions are projected to increase by 35–60 percent by 2030 due to increased nitrogen fertilizer use and animal manure production (Smith et al. 2007a). Given the increase in meat consumption associated with economic growth, livestock production is expected to increase, leading to an increase in CH_4 emissions of 60 percent by 2030 (ibid.). Verchot (2007) estimates that total non-CO_2 emissions from agriculture will also be 60 percent higher in 2030 than they were in 1990. N_2O increases will be driven mainly by agricultural soils, while CH_4 emission increases can be attributed to enteric fermentation and rice production.

Table 6. Baseline for non-CO_2 greenhouse gas emissions ($MtCO_2e$) by source through 2030

	Year								
Source	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
N_2O soil	2,284	2,405	2,610	2,782	2,996	3,252	3,542	3,774	4,006
N_2O manure	196	199	205	219	230	246	261	274	288
CH_4 enteric fermentation	1,772	1,804	1,799	1,929	2,079	2,204	2,344	2,473	2,601
CH_4 manure	223	225	225	235	244	257	269	282	294
CH_4 other	268	274	455	456	456	456	456	456	456
CH_4 rice	601	621	634	672	708	744	776	812	848
Global total	5,343	5,528	5,928	6,291	6,713	7,158	7,648	8,071	8,493

Source: Verchot 2007
Note: CH_4 = methane; CO_2 = carbon dioxide; $MtCO_2e$ = mega tons of carbon dioxide or equivalent; N_2O = nitrous oxide

While forest areas in industrialized countries are projected to increase by 60 to 230 million hectares between 2000 and 2050, this increase will be offset by decreases in forest areas in developing regions of 200 to 490 million hectares over the same period (MEA 2005). A baseline scenario regarding global GHG emissions from the forestry sector is harder to establish given a lack of consensus on factors that control the carbon balance and is the subject of much research (Nabuurs et al. 2007). Estimates of GHG emissions and removals from the forestry sector vary widely across studies based on land-use types included and on the use of gross fluxes versus net carbon balance, among other factors (ibid.).

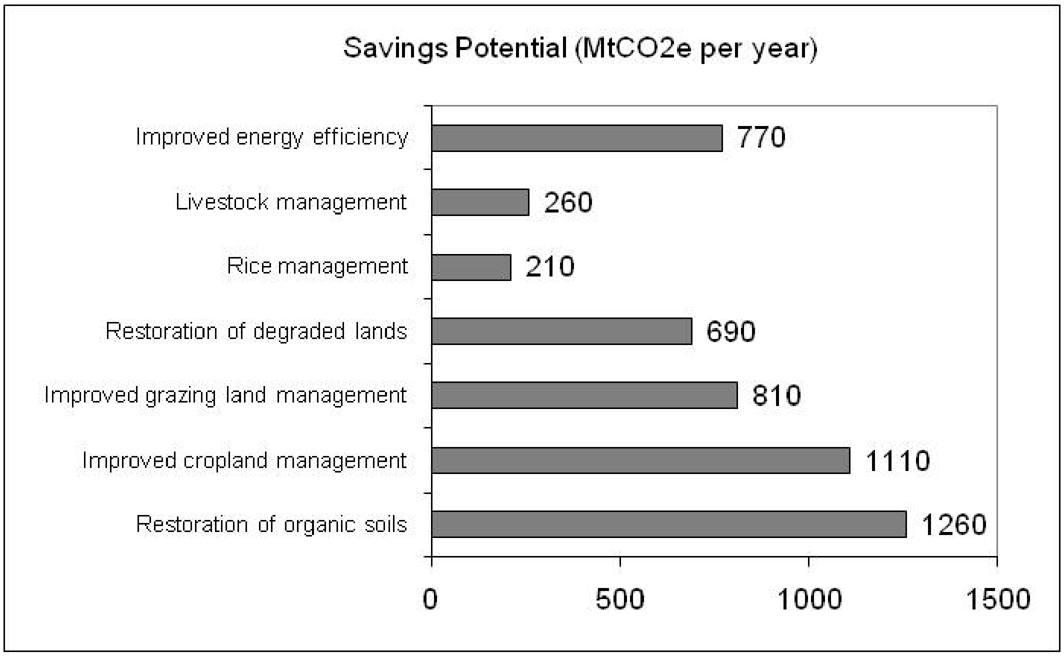
5. MITIGATION POTENTIAL IN AGRICULTURE AND LULUCF

5.1. Agriculture

There have been many attempts to estimate the potential technical and economic emissions savings from mitigation measures in agriculture. Technical potential refers to the amount of GHG emission savings possible in the absence of any political, economic or other constraints. Economic potential refers to the amount of GHG emission savings that would occur through market transactions given various carbon prices. Many studies focus on mitigation potential from soil carbon sequestration. Considering all GHGs, Smith et al. (2008) estimate that by 2030 the technical potential for mitigation through agriculture is between 5,500 and 6,000 $MtCO_2e$ and the economic potential is between 1,500 and 4,300 $MtCO_2e$ at a range of carbon prices (up to US$100 per tCO_2e). The report further estimates that of this total mitigation potential, 89 percent is from carbon sequestration in agricultural soils and 9 percent and 2 percent are from mitigation of CH_4 and N_2O, respectively (ibid.).

Smith et al. (2008) estimate the potential GHG savings by 2030 for the most prominent mitigation options in agriculture (see Figure 5).

Figure 5. Potential savings by 2030 from mitigation options in agriculture for carbon prices of up to US$100 per ton of carbon dioxide or equivalent



Source: Smith et al. 2008
Note: $MtCO_2e$ = mega tons of carbon dioxide or equivalent

Considering all gases, the researchers find that the global technical mitigation potential from agriculture by 2030 is estimated to be 5,500–6,000 $MtCO_2e$ per year. Of the total mitigation potential, about 89 percent is from reduced soil emissions of CO_2, about 9 percent is from mitigation of CH_4, and about 2 percent is from mitigation of soil N_2O emissions. Similarly, Caldeira et al. (2004) estimate technical savings of approximately 4,500 $MtCO_2e$ per year, considering no economic or other barriers.

Economic potential, which takes carbon trading into consideration, varies according to carbon prices and is estimated at 1,500–1,600, 2,500–2,700, and 4,000-4,300 $MtCO_2e$ per year at carbon prices of up to US$20, up to US$50, and up to US$100 per tCO_2e, respectively (Smith et al. 2008). According to

Smith et al., the technical potential for mitigation through agriculture in Africa is 970 $MtCO_2e$ per year by 2030, and the economic potential (assuming prices of up to US$20 per tCO_2e) is 265 $MtCO_2e$.

GHG emissions could be further reduced by substituting agricultural feedstocks (e.g., crop residues, dung, and dedicated energy crops) for fossil fuels for energy production. The economic mitigation potential of biomass energy from agriculture is estimated to be 640, 2,240, and 16,000 $MtCO_2e$ per year at up to US$20, up to US$50, and up to US$100 per tCO_2e, respectively (ibid.).

While the total biophysical potential of approximately 5,500–6,000 $MtCO_2e$ per year will not be realized, agriculture can make a significant contribution to climate mitigation by 2030. Total annual anthropogenic CO_2 emissions during the 1990s were approximately 20,000 $MtCO_2e$ per year, so agriculture could offset, at full biophysical potential, about 30% of total annual CO_2 emissions, with offsets of approximately 8 percent, 13 percent, and 20 percent at prices of up to US$20, up to US$50, and up to US$100 per tCO_2e.

While agricultural emissions are highest in Asia and Latin America, the Middle East and North Africa and Sub-Saharan Africa have the highest projected growth rate in agriculture-related emissions, at 95 percent between 1990 and 2020, driven by the growing wealth of urban populations and consequent rising demand for livestock products, the intensification of agricultural production, and expansion into unexploited areas (Smith et al. 2007a; USEPA 2006a; Verchot 2007). Baseline estimates by the U.S. Environmental Protection Agency (USEPA) show total GHG emissions from agriculture in Africa increasing until 2020 (see Table 7).

Table 7. Baseline emissions from all agriculture ($MtCO_2e$)

Country/Region	2000	2010	2020
Africa	**301**	**364**	**431**
Annex I countries	1,258	1,230	1,297
Brazil	249	292	327
China	789	791	876
India	417	441	480
United States	338	351	370
World total	4,563	4,417	4,822

Source: USEPA 2006b
Note: $MtCO_2e$ = mega tons of carbon dioxide or equivalent

Table 7 shows that Africa is comparable to India and the United States in terms of the amount of GHG emissions from agriculture. Thus, there is great potential for climate-change mitigation from this sector. The USEPA (2006b) estimates potential emission savings at different carbon prices for selected regions and countries (Table 8). At carbon prices of US$60 per tCO_2e, Africa can reduce emissions from its baseline estimate by 4.4 percent. While the total potential for emission reductions from agricultural production in Africa is less than that of the other countries and regions presented in Table 8, the potential savings from particular mitigation options such as cropland management in Africa are greater—14.2 percent at US$60 per tCO_2e, compared to 12.4 percent for Brazil, 12.5 percent for China, and 11.5 percent for India at the same price.

Table 8. Total agriculture: Percentage reductions from baseline (see Table 7) at different prices (US$ per tCO_2e)

	2010			2020		
Country/Region	**$0**	**$30**	**$60**	**$0**	**$30**	**$60**
Africa	1.6%	3.6%	4.5%	1.4%	3.5%	4.4%
Annex I countries	11.1%	18.1%	20.0%	10.8%	16.2%	19.6%
Brazil	3.2%	5.8%	7.2%	3.1%	5.6%	7.0%
China	7.8%	14.1%	15.0%	6.3%	12.1%	12.9%
India	1.6%	9.5%	9.7%	1.5%	9.3%	9.3%
United States	14.2%	22.9%	25.0%	13.8%	23.4%	24.9%
World total	7.1%	12.5%	14.3%	6.7%	11.6%	13.4%

Source: USEPA 2006b
Note: tCO_2e = ton of carbon dioxide or equivalent

A recent study assesses the technical and economic mitigation potential of various agricultural practices within different African regions (Smith et al. 2008). These results are presented in Table 9. As shown in the table, mitigation potential is largest in East, West, and Central Africa, with mitigation potentials of 109, 60, and 49 $MtCO_2e$ per year, respectively. The agricultural practices that appear promising include cropland management (69 $MtCO_2e$ per year), grazing land management (65 $MtCO_2e$ per year), and restoration of organic soils (61 $MtCO_2e$ per year).

Table 9. Estimated economic mitigation potential by management practice and region

	Economic Mitigation Potential by 2030 at Prices of up to US$20 per tCO_2e ($MtCO_2e$ per year)					
	Cropland management	**Grazing land management**	**Restoration of organic soils**	**Restoration of degraded land**	**Other practices**	**Total**
East Africa	28	27	25	13	15	109
Central Africa	13	12	11	6	7	49
North Africa	6	6	6	3	3	25
Southern Africa	6	5	5	3	3	22
West Africa	16	15	14	7	8	60
Total	69 (26%)	65 (25%)	61 (23%)	33 (12%)	37 (14%)	265

Source: Smith et al. 2008
Note: $MtCO_2e$ = mega tons of carbon dioxide or equivalent

5.2. Land-Use Change and Forestry

Two different approaches to estimating the mitigation potential of LULUCF are used in the literature: (1) regional, bottom-up assessments by country or continent or (2) global forest- or multisector models (Nabuurs et al. 2007). Even within similar types of studies, estimates vary due to differences in basic assumptions, mitigation options considered, and methodologies applied (ibid.). These issues, plus the difficulty of establishing a widely agreed upon baseline for emissions from the forestry sector, create uncertainty regarding the overall mitigation potential of the sector. With this note of caution, following are the results of several studies on the economic potential for mitigation in the forestry sector.

Several regional studies examine the potential for savings from avoided deforestation in the tropics. According to Jung (2003), 93 percent of the mitigation potential in tropical regions over the short term is related to avoided deforestation. Over the long term (50 years), Sohngen and Sedjo (2006) estimate that deforestation could be eliminated at carbon prices of US$27.2 per tCO_2 (a net gain of 278,000 $MtCO_2$) or reduced by 18,000 $MtCO_2$ at a price of US$1.36 per tCO_2. Other studies examine the potential of both avoided deforestation and afforestation. Sathaye et al. (2005) estimate that by 2050, the potential from both avoided deforestation and afforestation/reforestation is 13,570 $MtCO_2$ at a price of US$5 per tCO_2 + 5 percent annual carbon price increment, and 15,628 $MtCO_2$ at a price of US$10 per tCO_2 + 3 percent per year. Full results are reported in Table 10.

Table 10. Carbon benefits gained across scenarios of carbon prices

	Carbon Price (US$ per tCO_2)		**Carbon Sequestered ($MtCO_2$)**	
2010 Carbon Price + Annual Increase	2050	2100	2050	2100
US$5 + 5%	35	404	13,570	70,145
Forestation			5,554	33,162
Avoided deforestation			8,034	37,105
US$10 + 3%	33	143	15,628	50,905
Forestation			4,934	16,358
Avoided deforestation			10,694	34,547
US$20 + 3%	65	286	28,582	79,559
Forestation			8,917	28,575
Avoided deforestation			19,665	50,985
US$100 + 0%	100	100	47,252	78,970
Forestation			13,587	17,245
Avoided deforestation			33,665	61,725

Source: Sathaye et al. 2005
Note: $MtCO_2$ = mega tons of carbon dioxide

Using a global model, Benitez-Ponce et al. (2007) project that annual sequestration from afforestation and reforestation would average 510 $MtCO_2$ per year for the first 20 years and 805 $MtCO_2$ per year for the first 40 years at a price of US$13.6 per tCO_2. Global models show that reduced deforestation in Central and South America has the greatest mitigation potential, followed by reduced deforestation in Africa, Asia, and the United States (see Table 11). Africa’s potential of 1,925 $MtCO_2e$ per year accounts for 14 percent of the global total. Even more important, Africa’s avoided-deforestation potential of 1,160 $MtCO_2e$ per year accounts for 29 percent of the global total.

Table 11. Potential of mitigation measures of global forestry activities, global model results

Region	Activity	Potential at Costs Equal or Less Than US$100 per tCO_2, in $MtCO_2$ per year in 2030
United States	Afforestation	**445**
	Reduced deforestation	**10**
	Forest management	**1,590**
	Total	**2,045**
Europe	Afforestation	**115**
	Reduced deforestation	**10**
	Forest management	**170**
	Total	**295**
OECD Pacific	Afforestation	**115**
	Reduced deforestation	**30**
	Forest management	**110**
	Total	**255**
Non–Annex I East Asia	Afforestation	**605**
	Reduced deforestation	**110**
	Forest management	**1,200**
	Total	**1,915**
Countries in transition	Afforestation	**545**
	Reduced deforestation	**85**
	Forest management	**1,055**
	Total	**1,685**
Central and South America	Afforestation	**750**
	Reduced deforestation	**1,845**
	Forest management	**550**
	Total	**3,145**
Africa	**Afforestation**	**665**
	Reduced deforestation	**1,160**
	Forest management	**100**
	Total	**1,925**
Other Asia	Afforestation	**745**
	Reduced deforestation	**670**
	Forest management	**960**
	Total	**2,375**
Middle East	Afforestation	**60**
	Reduced deforestation	**30**
	Forest management	**45**
	Total	**135**
TOTAL	Afforestation	**4,045**
	Reduced deforestation	**3,950**
	Forest management	**5,780**
	Total	**13,775**

Source: Nabuurs et al. 2007
Note: $MtCO_2$ = mega tons of carbon dioxide

As shown above, despite differences in estimates and methods, both regional and global studies show that there is great potential for climate-change mitigation through forestry activities, particularly in tropical areas. Thus, mitigation through the forestry sector should be a high priority in areas where deforestation is projected to continue. The options for mitigation in the agriculture and forestry sectors are discussed below.

5.3. Mitigation Options in the Agriculture and Forestry Sectors

Given the projected increases in GHG emissions related to LULUCF and agricultural production in Africa, these sectors have significant potential to contribute to climate-change mitigation. Several mitigation options are available in these two sectors. Mitigation options fall into three broad categories based on the mechanism for mitigation: reducing emissions into the atmosphere, enhancing removal of carbon from the atmosphere, or replacing fossil fuels with biofuels (Smith et al. 2007a). Specific options include (1) cropland management (enhancing yields, managing nutrients, reducing tillage, increasing water productivity, encouraging the conversion of cropland to another land cover), (2) grazing land management and pasture improvement (management of grazing intensity, increasing productivity, nutrient management, fire management, species introduction), (3) management of organic or peaty soils, (4) restoration of degraded lands, (5) livestock management (improving feeding practices, dietary additives, animal breeding), (6) manure management, and (7) bioenergy use (ibid.). Some of these mitigation practices affect more than one GHG, while some mainly affect one GHG. Practices that affect emissions at one site may be less effective in another. Thus, mitigation options should be chosen to suit individual agricultural systems (ibid.).

Options for reducing emissions from the forest sector include (1) maintaining or increasing the forest area through avoided deforestation and through afforestation/reforestation; (2) maintaining or increasing the stand-level carbon density (tons of carbon per hectare) through the reduction of forest degradation and through planting, site preparation, tree improvement, fertilization, uneven-aged stand management, or other techniques; (3) maintaining or increasing the landscape-level carbon density using forest conservation, longer forest rotations, fire management, and protection against insects; and (4) increasing off-site carbon stocks in wood products, enhancing product and fuel substitution using forest-derived biomass to substitute products with high fossil fuel requirements, and increasing the use of biomass-derived energy to substitute fossil fuels (Nabuurs et al. 2007).

Among the mitigation options discussed above, certain options are better suited for the African region and have greater mitigation potential there. For instance, within agriculture, cropland management in Africa has great mitigation potential, while changes in rice production practices are less important in Africa than in Asia. With regard to LULUCF, the potential for mitigation from avoided deforestation in Africa is high (1,160 $MtCO_2$ per year) compared to afforestation (665 $MtCO_2$ per year) or forest management (100 $MtCO_2$ per year), which have minimal potential to reduce emissions in Africa (Table 11).

Yet there are a number of constraints that prevent Africa from participating in carbon markets and implementing the above-mentioned projects, which would reduce GHG emissions. The following sections describe these constraints and point to ways in which these limitations can be overcome.

6. CONSTRAINTS TO SSA PARTICIPATION IN GLOBAL CARBON MARKETS

6.1. Constraints to Participation in the CDM

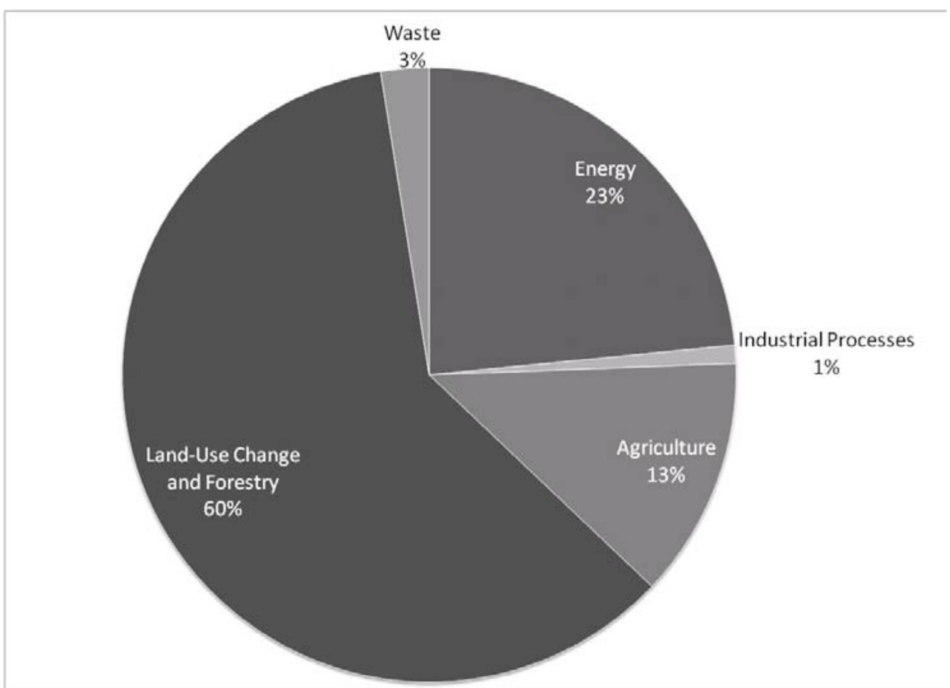
Although all 15 project categories listed in Table 3 are eligible for credit under the CDM, in its current form the CDM is mainly focusing on industrial-level energy and power sources. Afforestation and reforestation projects have also been emphasized for carbon credits under the CDM during the first commitment period (i.e., 2008–2012), while carbon sequestration from averted-deforestation projects and from agriculture, which are very important areas for climate mitigation in many African economies, have been systematically excluded or downplayed (UNFCCC 2001; Pearson, Walker, and Brown 2006). Consequently, Africa's share of the CDM market is lower than its share of foreign direct investment (FDI) with respect to other developing countries over the past few years.

While there is significant potential to mitigate GHG emissions by including activities in the agriculture and forestry sectors in carbon markets, the rules of the game under the CDM are biased against Africa and other poor developing countries. To be considered eligible to engage in carbon trading under the CDM, a project must meet several criteria. These include establishing a clear baseline and demonstrating that emission reductions would not have occurred in the absence of the project (the concept of additionality). Other rules and factors that constrain participation include leakages, the cost-effectiveness of the projects, irreversibility, high transaction costs, property rights, and uncertainty (Smith and Scherr 2003). The following sections describe these constraints in greater detail.

6.1.1. Exclusion of Soil Carbon Sequestration and Avoided Deforestation

Soil carbon sequestration and avoided deforestation are important areas for climate-change mitigation. As shown above, the potential savings from these activities is high. Africa's avoided-deforestation potential of 1,160 $MtCO_2e$ per year accounts for 29 percent of the global total (Nabuurs et al. 2007), and the potential for mitigation through agriculture in the African region is estimated at 970 $MtCO_2e$ per year until 2030, which is 17 percent of the global total (Smith et al. 2008).

Figure 6. Share of greenhouse gas emissions by sector in Sub-Saharan Africa



Source: CAIT 2008

Furthermore, given that land-use change, forestry, and agriculture are the main sources of GHG emissions in the least-developed countries (see Figure 6), such as those in Sub-Saharan Africa, the inclusion of projects in these areas has the potential to promote pro-poor mitigation by encouraging the inclusion of poor countries in the CDM. Yet projects related to soil carbon sequestration and avoided deforestation remain excluded from the CDM, thereby preventing the participation of low-income countries and hindering mitigation efforts.

6.1.2. Defining the Baseline

The baseline scenario describes GHG emission activity in the absence of the project. Baseline estimates exclude emissions that would have to be removed to comply with national or local safety requirements or legal regulations. The three most common methods for establishing the baseline are benchmarking, technology matrix, and top-down baseline. With benchmarking, the host country establishes default emission rates for different sectors, subsectors, or regions, and any emission rate over and above the level that is likely to be achieved with the implementation of the project would be considered additional. Under the technology matrix, a number of predefined default technologies are identified as the baseline technologies for a defined region and for a specified time, and the emission baseline for a project would equal the emission rate for the specified technology. Consequently, any projects that introduced technologies with GHG emissions lower than the specified baseline technology would be considered as providing additional reductions. Finally, the top-down baseline is determined by a host government. It allows a country to assess project additionality in the context of its overall planning effort to mitigate climate change.

The two most important requirements for designing an adequate baseline are technical know-how and availability of data. It has been noted that in most cases historical data are readily available but reflect dirtier technologies, indicating that enormous “unfair” gains could be made if the project leads to a drastic shift toward much cleaner technology. It has therefore been recommended that if historical data are used, some higher standards such as new additions within the last 10 years or top-25-percent performers could be used (Kelly 1999). Alternatively, if projected data exist, they could be used to create tougher benchmarks, under the assumption that the host countries will not take advantage of the uncertainties associated with forecast data. For many countries in SSA, a lack of technical training and support in setting benchmarks as well as poor data availability and quality are obstacles to defining an adequate baseline (ibid.).

6.1.3. The Additionality Criterion

A project is said to meet the additionality criterion if the carbon sequestration or emission reductions achieved by the project would not have been achieved in the absence of incentives provided by the CDM (i.e., baseline). The carbon credits earned reflect the difference in emissions with and without the project activities.

To demonstrate additionality, the following steps must be followed[26]:

1. Alternatives to the project activity should be identified.
2. An investment analysis must be performed to show that the proposed project activity is not the most financially attractive or beneficial.
3. Barriers that could prevent the implementation of the proposed project but do not prevent the implementation of at least one of the alternatives should be presented.
4. A common-practice analysis that examines the extent to which the project type has already been diffused in the relevant sector or region should be performed.
5. How registration of the project as a CDM activity enables the project to be undertaken should be explained.

[26] This information is taken from the UNFCCC report available at http://cdm.unfccc.int/EB/Meetings/016/eb16repan1.pdf.

Additionality is advocated because if a CDM project—say, reforestation—would have been undertaken either through deliberate management action or natural processes, then allowing the CDM transaction to take place would permit the Annex I country to emit more GHGs. The net level of emissions would therefore be higher than if the transaction had not taken place (Pearson, Walker, and Brown 2006).

By definition, afforestation or reforestation projects comprise human-induced conversion of nonforest land uses to forest, through planting, seeding, and/or human-induced promotion of natural seed sources. Afforestation differs from reforestation only in that afforestation takes place on land that has not been forested for at least 50 years, while reforestation refers to land that did not contain forest on December 31, 1989 (Smith and Scherr 2003; Pearson, Walker, and Brown 2006). In practice, however, no distinction is made under the CDM between afforestation and reforestation. Land that is eligible for afforestation or reforestation under the CDM should have been (a) nonforest on December 31, 1989, and (b) nonforest at the initiation of project activity. This requirement seeks to prevent landowners from cutting down their forest in order to meet the eligibility criteria for carbon credit under the CDM (Pearson, Walker, and Brown 2006). The definition of a forest under the CDM allows some flexibility. The designated national authorities, which are national presiding authorities in non–Annex I countries, have the responsibility to decide on the limit within the following thresholds:

1. Minimum tree crown cover value between 10 and 30 percent
2. Minimum land area value between 0.05 and 1 hectare
3. Minimum tree height value between 2 and 5 meters

Additionality can be difficult to demonstrate for agriculture and forestry projects, since many mitigation possibilities are financially viable and are already occurring. It is therefore difficult to determine how much of an activity can be attributed to the CDM (Smith et al. 2007b). Moreover, for forest projects, the definition of a high crown cover may exclude agroforestry projects or low-stature trees, whereas a "low" definition may exclude degraded areas with sparse tree cover in the baseline. A high value for minimum land area encourages areas with real environmental and biodiversity benefits but excludes typical community forests and agroforests around dwellings.

The UN climate conference in Bali in 2007 agreed to include forest conservation in future discussions on a new global warming treaty. Reducing emissions from deforestation and degradation (REDD) was considered a potentially cost-effective way to address environmental degradation by assigning value to intact ecosystems such as rainforests and peat swamps. The UK government's 2005 Stern Review also acknowledged forest protection as one of the most cost-effective ways to address climate change. Given the high rate of deforestation in Africa, this is welcome news for CDM projects related to afforestation, reforestation, and averted deforestation. However, rather than paying for projects directly, REDD is designed to operate with rewards accruing nationally or subnationally (Luttrell, Schreckenberg, and Peskett 2007).

6.1.4. Other Constraints to Carbon Market Participation

In addition to the problems due to project exclusions and the baseline and additionality requirements, Africa's participation in the CDM is also constrained by a number of other factors, as discussed below.

- **Leakages**

The adoption of certain agricultural practices or forest conservation or reforestation efforts may reduce emissions in a given area or region. However, emission savings could be offset if agricultural production shifts to other regions where little effort is expended on mitigation measures in agriculture or forest conservation efforts (Smith et al. 2007b). Community-based agriculture and forestry projects will result in leakages if the project takes over community land and does not adequately compensate the community. For example, projects that displace significant annual crop production need to simultaneously increase the productivity of agricultural land through labor-intensive technologies. Thus, livelihood-enhancing projects that are likely to adequately meet the needs of local communities reduce the risk of leakage. In practice, however, considerable difficulties may occur in fulfilling community needs in developing countries.

- **Cost-effectiveness**

Production cost is defined as the cost of establishing and maintaining the new carbon-sequestering land use for the duration of the project, divided by the total carbon benefits accumulated by the project during its existence. For afforestation and reforestation projects, production costs include tree establishment, tree management and processing, and the opportunity cost of land. In the case of averted-deforestation projects, these costs include compensatory payments to the sources of deforestation threats, as well as the cost of measures to prevent future deforestation (such as the costs of patrolling the area and establishing sustainable community forestry or ecotourism within the project area). Although the level of carbon benefits used for calculating production costs should be adjusted for additionality and leakage, very few estimates do so. Therefore, most figures should be taken as underestimates of the cost of supplying carbon services. Studies have shown that the production costs for afforestation and reforestation projects such as agroforestry systems and community plantations are often higher than the costs of industrial plantations. Assisted natural regeneration, in contrast, tends to be much less expensive than tree planting because typically it includes low-cost techniques such as the restriction of grazing and the management of coppices and shoots. Moreover, the price of carbon in a full-fledged market is still highly uncertain, making it difficult to determine the cost-effectiveness of CDM projects.

- **Irreversibility**

When deciding on the number of CDM projects to be implemented, it is imperative that developing countries be aware that they may be facing their own emission-reduction commitments in the future. Since most emission-abatement measures are irreversible, ignoring possible future commitments could lead to some problems. Notably, the cheapest abatement measures will be implemented for CDM projects, leaving the developing countries with only more expensive measures when they have to meet their own commitments in the future.

- **High transaction costs**

The costs of carbon projects include the cost of providing information about carbon benefits to potential buyers, communicating with project partners, and ensuring that all parties fulfill their contractual obligations. Measurement and monitoring costs are also considerable. These transaction costs per unit of emission reduction seem likely to be much higher for projects involving local communities, as the costs of negotiating land-use decisions with large numbers of geographically dispersed local people with different land-use objectives in SSA will tend to be higher for a community-managed project than for most strict forest protection or industrial plantation projects. Some experts have therefore recommended that smaller-sized community projects be pooled to lower project development, marketing, certification, and insurance costs (Noble 2003; Smith and Scherr 2003).

Moreover, livelihood-enhancing projects such as agroforestry, community plantations, forest gardens, and secondary forest fallows often face significant institutional barriers such as difficulties in financing establishment costs and obtaining planting materials, and a lack of technical assistance or marketing infrastructure.

- **Uncertainty**

Uncertainty about gas emissions and carbon storage processes and measurement make investors more wary of these options and more likely to choose clearly defined industrial mitigation activities (Smith et al. 2007b). Thus, a greater effort must be made to demonstrate the significant savings available through agriculture and forestry projects.

- **Property rights**

Currently, one-half to two-thirds of the forests in developing countries are state owned, with overlapping access rights to forest products—such as logging concessions granted to timber companies in forests where local communities have customary-use rights. As a result, in the absence of supportive legislation, revenues may be captured only by those who have formal land titles, while communities with customary rights are excluded (White and Martin 2002).

- **Lack of development**

In its current form, the CDM is mainly focused on industrial-level energy and power sources. However, in Africa, energy or electricity access is limited. This reduces the mitigation opportunities through clean development of electricity projects.

6.2. Constraints to Participation in Other Carbon Markets

Other carbon markets have excluded major carbon assets such as LULUCF and agroforestry credits in their carbon transactions, making it difficult for many non–Annex I parties, including SSA countries, to participate in the emission trading system (Painuly 2001; Smith and Scherr 2003; Capoor and Ambrosi 2006). This has limited the potential benefits obtainable from the other large markets such as the EU ETS. Also, developing countries are not included in any numerical limitation of the Kyoto Protocol because they were not the main contributors to GHG emissions during the pretreaty industrialization period (Persson, Azar, and Lindgren 2006). Indeed, many African countries have thin energy and industrial sectors with limited opportunities to reduce carbon emissions (Capoor and Ambrosi 2006). However, even without the commitment to reduce emissions according to the Kyoto target, developing countries do share the common responsibility that all countries have in reducing emissions.

7. OPTIONS FOR INTEGRATING SSA INTO GLOBAL CARBON MARKETS

There are several options for making carbon markets more inclusive of SSA countries. Many of these options would also enable the poor within these countries to benefit from carbon trading by reducing the transaction costs associated with small-scale carbon offset projects. Expanding carbon markets within SSA would also increase the profitability of environmentally sustainable activities. For these reasons, there should be more political discussion and negotiation on the ways in which carbon markets should be expanded and how they can promote poverty reduction and environmental sustainability. Following are several options that should be explored further.

1. Simplify the rules of the game under the CDM

Rules for accessing carbon markets should be simplified. The successful inclusion of avoided-deforestation and soil carbon sequestration projects in the CCX demonstrates that these activities could be included in the CDM by simplifying rules for issuing credits and using modern monitoring techniques while simultaneously reducing transaction costs (Rosegrant 2007). According to the Marrakesh Accords, small-scale projects, such as agroforestry and community forestry projects, whose annual emission offsets are less than 15,000 tCO2, can benefit from simplified ways of determining baselines, monitoring carbon emissions, and enforcing offsets. Simplified emission-reduction credits could be calculated using standardized reference emission rates for different emission-reduction or storage activities in specific locations, as determined and verified by independent bodies; an uncertainty discount could be applied. These changes could significantly reduce the transaction costs of community-based projects and expand participation in carbon markets—not only of SSA countries but of poor rural communities (ibid.).

CCX rules regarding soil carbon and forestry projects are simplified yet remain rigorous, requiring annual verification by a third party. Currently, under the CCX, eligible agricultural soil carbon sequestration projects include grass planting and continuous conservation tillage. To qualify for agricultural soil carbon offsets, the project must include a minimum five-year commitment to a tillage practice that leaves two-thirds of the soil surface undisturbed and two-thirds of the crop residue on the surface. The project must also conserve between 0.2 and 0.6 $MtCO_2$ per acre per year, enroll through a registered offset aggregator (administrative entity representative of the offset project owners), and be independently verified (see http://www.chicagoclimatex.com). Eligible projects in the forestry sector include afforestation, forest management, urban tree planting, and forest conservation projects. Contracts are issued to forest enrichment projects on unforested or degraded forest land (including urban tree planting) at a rate based on the annual increase in the carbon stocks of above-ground, living biomass. In a key breakthrough, forest conservation credits for combined conservation and forestation projects on contiguous sites are credited on the basis of the avoided-deforestation rates specified for eligible geographic regions. Quantification methods for forest carbon stocks vary by project size to reduce transaction costs for smaller projects. Carbon in small to medium afforestation projects (under 12,500 $MtCO_2$) is assessed through CCX carbon accumulation tables or direct methods (direct in-field sampling and measurement). In large projects, carbon accumulation is measured directly or determined by properly parameterized growth models.

2. Broaden the CDM definition of afforestation and reforestation

Many projects currently not included in the CDM definition of afforestation and reforestation offer great mitigation potential and would present an opportunity for greater SSA participation. The definition of afforestation and reforestation should be expanded to include agroforestry, assisted natural regeneration, forest rehabilitation, forest gardens, and improved forest fallow projects, all of which offer a low-cost approach to carbon sequestration while presenting fewer social risks and significant community and biodiversity benefits (Smith and Scherr 2003; Rosegrant 2007). Short-duration tree-growing activities should also be permitted, with suitable discounting (Rosegrant 2007). Limiting project types introduces forest product market distortions that unfairly favor large plantations (ibid.).

3. **Allow soil carbon sequestration and avoided-deforestation projects under the CDM**

Given that the largest share of emissions in SSA countries comes from deforestation and agricultural practices, including projects that prevent deforestation and reduce soil carbon emissions from agriculture under the CDM would not only increase SSA's participation in global carbon markets but would also increase mitigation. Given the clear trends of tropical deforestation in the developing world and the widespread degradation of forests due to unsustainable logging, it would be possible to demonstrate additionality for either strict forest protection projects or multiple-use forest management. Similarly, the baseline trends and mitigation potentials of various agricultural practices have already been established (see Smith et al. 2008), facilitating the inclusion of carbon offset projects in the agriculture sector.

4. **Establish international capacity-building and advisory services**

The successful promotion of livelihood-enhancing CDM forestry and agriculture projects requires an investment in capacity-building and advisory services for potential investors, project designers and managers, national policymakers, and leaders of local organizations and federations (Rosegrant 2007). Regional centers could be established to assist countries and communities involved in forest carbon trading, while companies or agencies could provide specialized business services for low-income producers to help them negotiate deals or design monitoring systems (ibid.). Further investment in advanced measurement and monitoring could also dramatically reduce transaction costs. Measurement and monitoring techniques have been improving rapidly, thanks to a growing body of field measurements and the use of statistics and computer modeling, remote sensing, global positional systems, and geographic information systems, allowing changes in stocks of carbon to be estimated more accurately at a lower cost (ibid.).

5. **Award credits under the CDM to countries with clean development**

While the CDM is mainly focused on industrial-level energy and power sources, in Africa, energy or electricity access is a major challenge. Thus, mitigation opportunities through clean development are limited. In most SSA countries, less than 10 percent of the population has access to the electricity grid. Yet under CDM rules, a clean, grid-connected electricity project in one of these countries must demonstrate that it displaces "carbon-intensive" electricity on its grid. Even when these countries have access to electricity, the fact that they derive power mainly from clean hydro sources is seen as a reason for them not to receive credits for clean energy sources, given the baseline and additionality requirements. This unnecessarily punishes the poorest of the poor countries, which can least afford to use dirty but expensive electricity sources. Methodologies must be developed through which countries generating clean energy sources with low emissions are rewarded.

6. **Increase participation in voluntary markets**

Given the limitations of the CDM, African countries should aim to participate more in the emerging and fast-growing voluntary carbon markets, including the CCX and non-compliance-based voluntary markets. Voluntary markets have expanded rapidly over the past several years and are expected to continue to expand exponentially in the coming years with growing popular interest in mitigating climate change. Given their rapid expansion and the inclusion of a broader range of offset projects, including projects involving avoided deforestation and soil carbon sequestration, these markets present an opportunity for countries that have had limited access to the current compliance-driven global carbon market. In order to increase participation in these markets, African countries should raise awareness among both public and private stakeholders and develop institutional capacity and technical expertise for viable project development and implementation. Alternative sources of demand for carbon credits, such as voluntary markets, may have the flexibility to reward these efforts, regardless of the future development of the Kyoto-related compliance-driven markets.

7. **Carbon exchanges should involve local representative organizations**

Given the difficulty of maintaining contact with numerous local people, often in geographically dispersed areas, it is necessary to engage locally accountable intermediary organizations that are able to manage projects and mediate between investors and local people (Boyd, Gutierrez, and Chang 2007; Rosegrant 2007). Offset aggregators in the CCX are an example of an intermediary that brings together multiple offset-generating projects. Local stakeholder engagement ensures that project designs will be flexible, context-specific, socially acceptable, and sustainable (Boyd, Gutierrez, and Chang 2007). It also ensures that projects will be designed in a way that is not threatening to local livelihoods and does not result in leakage—shifting the carbon-producing activity to a new location. In contrast, top-down projects that do not involve local stakeholders while compromising their access to resources stand to fail and miss the opportunity to make carbon offset projects pro-poor (ibid.). Working with existing community-based organizations where links to local people have already been established offers clear benefits. In particular, communities with positive past experiences with development projects have much lower transaction costs. A carbon project in Chiapas, Mexico, estimated that the sociotechnical costs of capacity building varied from US$52 per hectare in communities with experience with community-managed projects to US$325 per hectare in communities with a high degree of communal divisions and social conflicts (de Jong, Tipper, and Montoya-Gómez 2000).

8. **Strengthen property rights**

Carbon markets created by global and national institutions may involve changing property rights regimes or overturning the traditional management of property rights (Brown and Corbera 2003). Currently, benefits may be captured by large landholders with clear property rights while communities with customary rights are excluded or inadequately compensated (Smith and Scherr 2003; White and Martin 2002). It is important that governments in SSA countries initiate processes to clarify forest rights and reject CDM projects where rights are unclear and overlapping, unless communities with customary rights participate in the decision-making process and benefits (Smith and Scherr 2003). Strengthening the property rights of local communities would ensure that these communities participate in defining and implementing carbon offset projects, and receiving the benefits created.

9. **Implement social assessments of projects**

Given the sustainable-development objectives of the CDM, greater international and national regulation of carbon offset projects is needed to ensure that social and environmental goals are met (Smith and Scherr 2003). Social impact assessments should be conducted to determine the extent to which standards are followed and communities benefit from carbon projects. Improving the regulation of carbon projects may also include establishing standards for how stakeholder consultations are conducted (ibid.).

8. CONCLUSIONS

The growth of Africa's agriculture places new demands on its environment and natural resources such as forestlands (which are declining at alarming rates) and croplands. Given that Africa's economic development will increase its energy demand in the near future, carbon trading could be a win-win-win situation for Africa in terms of conserving its natural resources, contributing to the good of the global environment, and generating income to finance its development activities.

The potential for Africa to contribute to GHG mitigation is large. Estimates show that at prices of US$60 per tCO_2e, Africa can reduce emissions from its baseline estimate by 4.4 percent by 2020 through changes in the agricultural sector. Africa also has great potential to contribute to GHG reductions through the forestry sector, with estimates showing a savings potential of 1,925 $MtCO_2$ per year (at a price of US$100 per tCO_2) by 2030. Particularly large are the potential savings from cropland management in Africa, at 14.2 percent (at a price of US$60 per tCO_2e) by 2020. The potential savings from avoided deforestation is 1,160 $MtCO_2$ per year (at a price of US$100 per tCO_2) by 2030.

For this potential to be realized, numerous barriers must be overcome. The gap between technical potential and realized GHG mitigation is a result of the barriers described in this paper, including the rules and factors surrounding current carbon markets, as well as the institutional (property rights), capacity, and economic constraints. The volume and type of agricultural mitigation options ultimately adopted will also depend upon the price of CO_2 equivalents.

For the SSA region, the mitigation mechanisms that show the greatest promise are either excluded from the CDM or other major trading schemes (in the case of avoided deforestation) or downplayed (in the case of agriculture and afforestation or reforestation) given various policy and technical constraints to implementation such as demonstrating additionality, establishing a baseline, preventing leakage, and high transaction costs.

But not all is gloomy. A number of CDM projects have been earmarked for SSA. These projects will sequester GHGs and also direct financial benefits to members of the local communities from the payment for environmental services and trade in nontimber forest products. The World Bank has mobilized a fund for demonstration projects that sequester or conserve carbon in forest and agro-ecosystems in developing countries, with a first tranche of US$53.8 million.

In view of this, SSA needs to strengthen its capacity and engage both private and public sectors in project development and implementation in order to take advantage of the flourishing carbon market. Simplifying the rules of the CDM regarding participation, measurement, and enforcement of offset projects; establishing international capacity-building and advisory services; awarding emission allowances and credits to developing countries; and increasing participation in voluntary markets would further integrate SSA countries into global carbon markets.

Policymakers should ensure that the benefits of carbon market participation are distributed equitably within countries and that the needs of the poor are taken into consideration. Working with intermediary organizations that are accountable to local producers, building community management capacity, strengthening property rights, and improving the regulation of offset projects to ensure social and environmental sustainability would ensure that the poor benefit from the carbon trading system while generating both income gains and environmental security. Achieving this result will require effective integration throughout the process, from the global governance of carbon trading to the sectoral and micro-level design of markets and contracts, as well as investment in community management.

APPENDIX

A.1. Basic Principles of the Kyoto Protocol

- Kyoto is underwritten by governments and is governed by global legislation enacted under the UN's aegis.
- Governments are separated into two general categories: developed countries, referred to as Annex I countries (which have accepted greenhouse gas [GHG] emission-reduction obligations and must submit an annual GHG inventory), and developing countries, referred to as non–Annex I countries (which have no GHG emission-reduction obligations but may participate in the Clean Development Mechanism [CDM]).
- Any Annex I country that fails to meet its Kyoto obligation will be penalized by having to submit 1.3 emission allowances in a second commitment period for every ton of GHG emissions by which the country exceeded its cap in the first commitment period (i.e., 2008–2012).
- By 2008–2012, Annex I countries must reduce their GHG emissions by an average of 5 percent below their 1990 levels (for many countries, such as the EU member states, this corresponds to some 15 percent below their expected GHG emissions in 2008). While the average emission reduction is 5 percent, national limitations range from 8 percent reductions for the European Union to a 10 percent emission increase for Iceland; but since the European Union intends to meet its target by distributing different rates among its member states, much larger increases (up to 27 percent) are allowed for some of the less-developed EU countries. Reduction limitations expire in 2013.
- Kyoto includes "flexible mechanisms" that allow Annex I economies to meet their GHG emission limitations by purchasing GHG emission reductions from elsewhere. These can be bought either from financial exchanges (such as the new unrelated-to-Kyoto EU Emission Trading Scheme [ETS]) or from projects that reduce emissions in non–Annex I economies under the CDM, or in other Annex I countries under the Joint Implementation (JI) scheme.
- Only CDM executive board–accredited Certified Emission Reductions (CERs) can be bought and sold in this manner. Under the aegis of the UN, Kyoto established this Bonn-based CDM executive board to assess and approve CDM projects in non–Annex I economies prior to awarding CERs. A similar scheme, called JI, applies in transitional economies (mainly covering the former Soviet Union and Eastern Europe).
- The cost of complying with Kyoto is prohibitive for many Annex I countries, especially those countries such as Japan and the Netherlands with highly efficient, low-GHG-polluting industries and high prevailing environmental standards. Kyoto therefore allows these countries to purchase carbon credits instead of reducing GHG emissions domestically. This is seen as a means of encouraging non–Annex I developing economies to reduce GHG emissions, as doing so is now economically viable due to the sale of carbon credits.

A.2. Clean Development Mechanism

The CDM arose out of the Kyoto Protocol negotiations in 1997. The U.S. government wished for as much flexibility as possible in achieving emission reductions and desired the possibility of international emissions trading to achieve cost-effective emission reductions. Eventually, the CDM and two other flexible mechanisms were written into the Kyoto Protocol.

Thus, the CDM is an arrangement under the Kyoto Protocol allowing industrialized countries with GHG reduction commitments (so-called Annex I counties) to invest in emission-reducing projects in developing countries as an alternative to what are generally considered more costly emission reductions in their own countries.

An industrialized country that wishes to receive credits from a CDM project must obtain the confirmation of the developing country hosting the project that it will contribute to sustainable development. Then, using methodologies approved by the CDM executive board, the applicant (the industrialized country in this case) must make the case that the project would not have been implemented anyway (establishing additionality) and must establish a baseline estimating the future emissions in the absence of the registered project. The case is then validated by a third-party agency, a so-called designated operational entity (DOE), to ensure that the project results in real, measurable, and long-term emission reductions. The executive board then decides whether or not to register (approve) the project. If a project is registered and implemented, the executive board issues credits, so-called CERs,[27] to project participants based on the monitored difference between the baseline and actual emissions, as verified by an external DOE.

[27] One CER is equivalent to 1 metric ton of carbon dioxide (CO_2) reductions.

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IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

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CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
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